The Role DISCOVER-AQ can play in OMI validation of NO2 and other species

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Introduction and Overview:

1) Summary: the NASA DISCOVER-AQ measurement campaigns can help meet OMI validation needs

2) Open issues for NO2 and aerosol retrievals: analyzing OMI column data with little or no vertical sensitivity alongside higher vertical resolution in-situ data

3) KNMI-developed NO2-sondes: can fill critical data gaps about the vertical distribution of NO2

4) Results: from the flexible multi-platform deployment from Balt/Wash July 2011 DISCOVER-AQ campaign

5) Future campaigns will feature the NO2-sonde: San Joaquin Valley (January 2013) and in Houston (September 2013).

1. Summary DISCOVER-AQ Goals:

DISCOVER-AQ = Deriving **I**nformation on **S**urface **C**onditions from **CO**lumn and **VER**tically Resolved Observations Relevant to **A**ir **Q**uality

Using a combination of ground-based and airborne platforms measurements of aerosols and key trace gases including O3, NO2, and CH2O will be measured on a variety of horizontal and vertical scale to explore correlations between surface and (satellite-based) column data and to identify vertical information can be used to improve interpretation of satellite column data.

Science Objectives & Expected Outcomes	Scientific Measurement Requirements	Instrument Functional Requirements	Investigation Functional Requirement
Objective 1: Relate column obs to surface conditions for aerosols, O3, NO2, and CH2O **Outcome:** Improved understanding of extent to which column obs can be related to surface conditions	Concurrent, urban-scale obs of column & in situ aerosols, O3, NO2, and CH2O from aircraft and ground sites	Active remote sensing of aerosol between surface and aircraft	Level flights mid-upper troposphere; Airborne profiling; Surface network; Ground-based lidars
Objective 2: Characterize differences in diurnal variation of surface and column obs for key trace gases & aerosols **Outcome:** Improved understanding diurnal variability as it influences interpretation of satellite obs and improved knowledge of factors controlling diurnal variability for testing and improving models	Continuous obs of column and in situ aerosols, O3, NO2, and CH2O throughout daylight hours Key trace gas and aerosol obs identifying influence of source emissions and chemistry	Passive remote sensing trace gas columns between surface and aircraft level Airborne obs of aerosol and trace gas profiles	All above plus: 8-hour flights with multiple aircraft to observe column and profile evolution Obs trace gas column at surface daylight hrs 24-hr obs of in situ trace gases and lidar aerosol profiles
Objective 3: Examine horizontal scales of variability affecting satellite and model calculations **Outcome:** Improved interpretation of satellite obs in region of steep gradients, better representation of urban plumes in models, and more effective assimilation of satellite data by models	Observe horizontal gradients in column and in situ aerosols, O3, NO2, and CH2O as well as pollution tracers CO, CO2, CH4, and reactive nitrogen	Passive remote sensing total columns for trace gases and AOD Ground-based, vertically-pointing lidar observations	High spatial resolution obs along flight transects to resolve 100m variability Extensive sampling different locations to characterize variation from emission, meteo, topography, surface optical parameters

Table 1. Summary of DISCOVER-AQ Science Traceability

2. Opportunity for OMI Validation:

Issues to address for NO2 Retrieval:
1) Profile Shape
2) Aerosol Interference
3) Impact of Surface Albedo

Issues to address for Aerosols:
1) Quantification of AAI
2) AOT Retrieval Aerosol Model Choice
3) Vertical Distribution of Aerosols

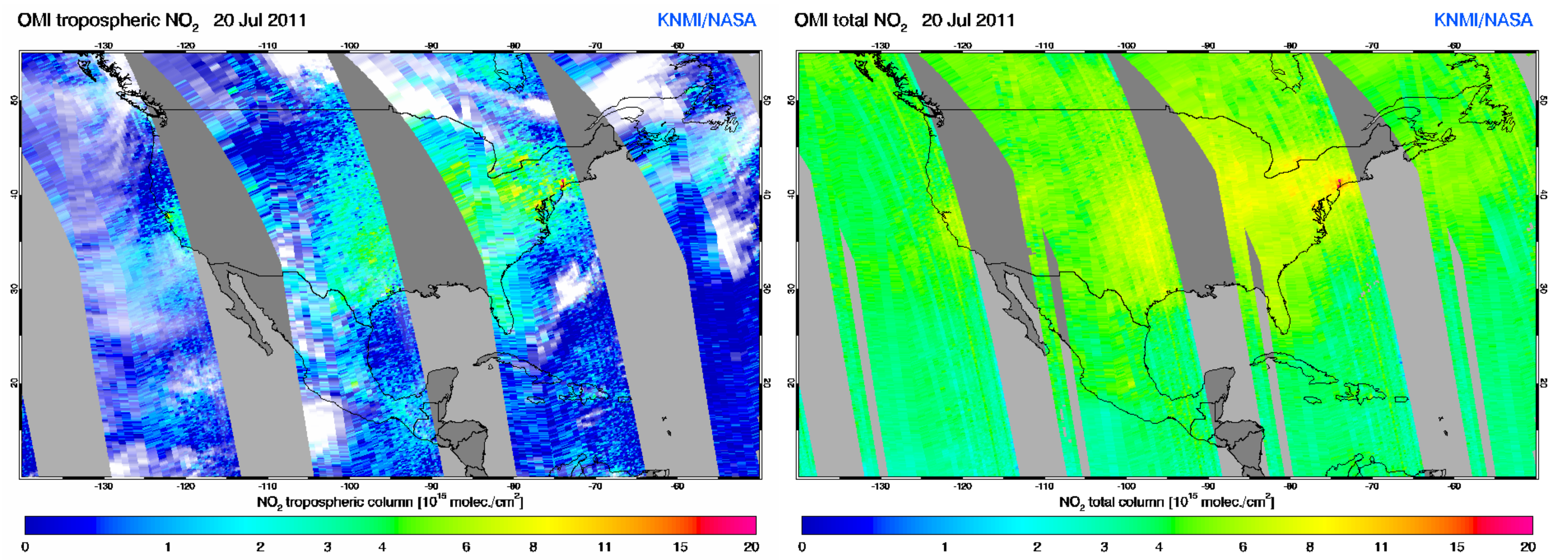
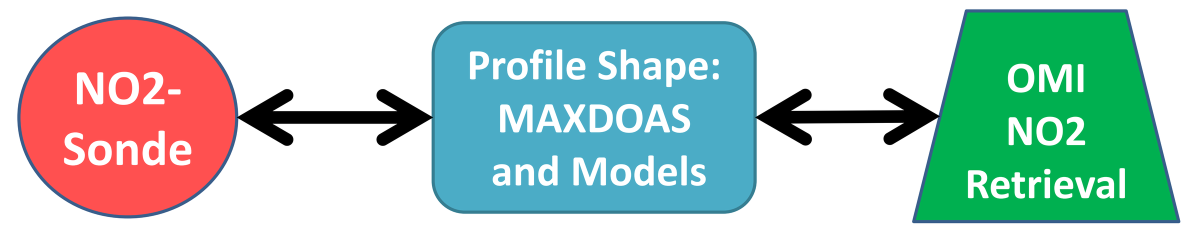


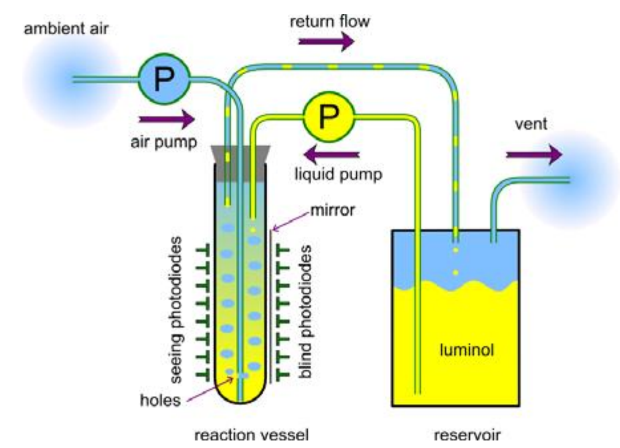
Figure 1: OMI NO2 (DOMINO) tropospheric (left), total column (right) for 20 July 2011



Step 1: Compare NO2-sonde profiles to model-derived and MAXDOAS profiles to improve understanding of profiles using the higher vertical resolution NO2-sonde data; **Step 2:** Use improved profile shape knowledge to update *a priori* information about NO2 vertical distribution in OMI retrieval.

3. NO_2-Sonde Overview:

The KNMI NO2-sondes use chemiluminescence with luminol (Fig 3, 4) to measure variations in concentration of NO2 in the boundary layer and free troposphere with high vertical resolution that OMI cannot detect. Photons are detected with a photodiode array and resulting currents are converted to voltages from the seeing, blind, and temperature channels, corrections for dark current, and individual sonde characteristics NO2 concentration can be derived. The NO2-sonde can be used with a tethersonde balloon, via traditional balloon-borne launches (**Fig 5**), and onboard an aircraft.



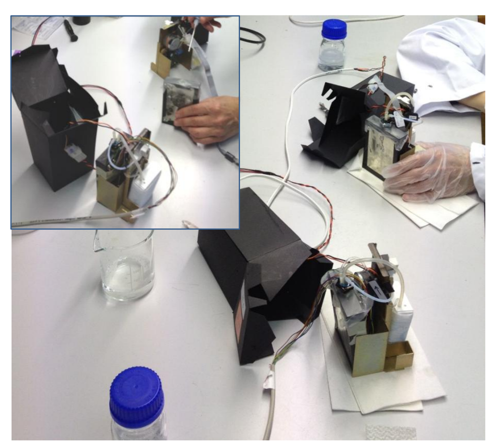


Figure 3, 4, 5. Schematic of NO2-sonde internal mechanism, photos of NO2-sonde preparation, and photo of NO2-sonde launch

The NO2-sonde yields 1-sec data, where the vertical resolution depends on the method of deployment and associated ascent rate. The sonde uses a housing similar to an ozonesonde coupled with a radiosonde for measuring temperature and pressure as well as tracking purposes. As the sonde is still in development it needs to be deployed in conjunction with other NO2-measurements to derive absolute NO2 concentrations. The DISCOVER-AQ will afford the opportunity for comparison with a be wide range of NO2-measuring instruments. In November 2012, the NO2-sonde will also undergo a series of lab tests to check sensitivity to a range of NO2 related species including PAN.

5. DISCOVER-AQ Results: NO_2-Sonde, Balt/Wash July 2011

TETHERSONDE RESULTS: Millersville University tethersonde measuring trace gases and aerosols included the NO2-sonde in its payload. In Figure 6, alternating NO / NOx profiles (left); NO2-sonde (right); **Black** (ascending profiles); **Blue** (descending profiles)

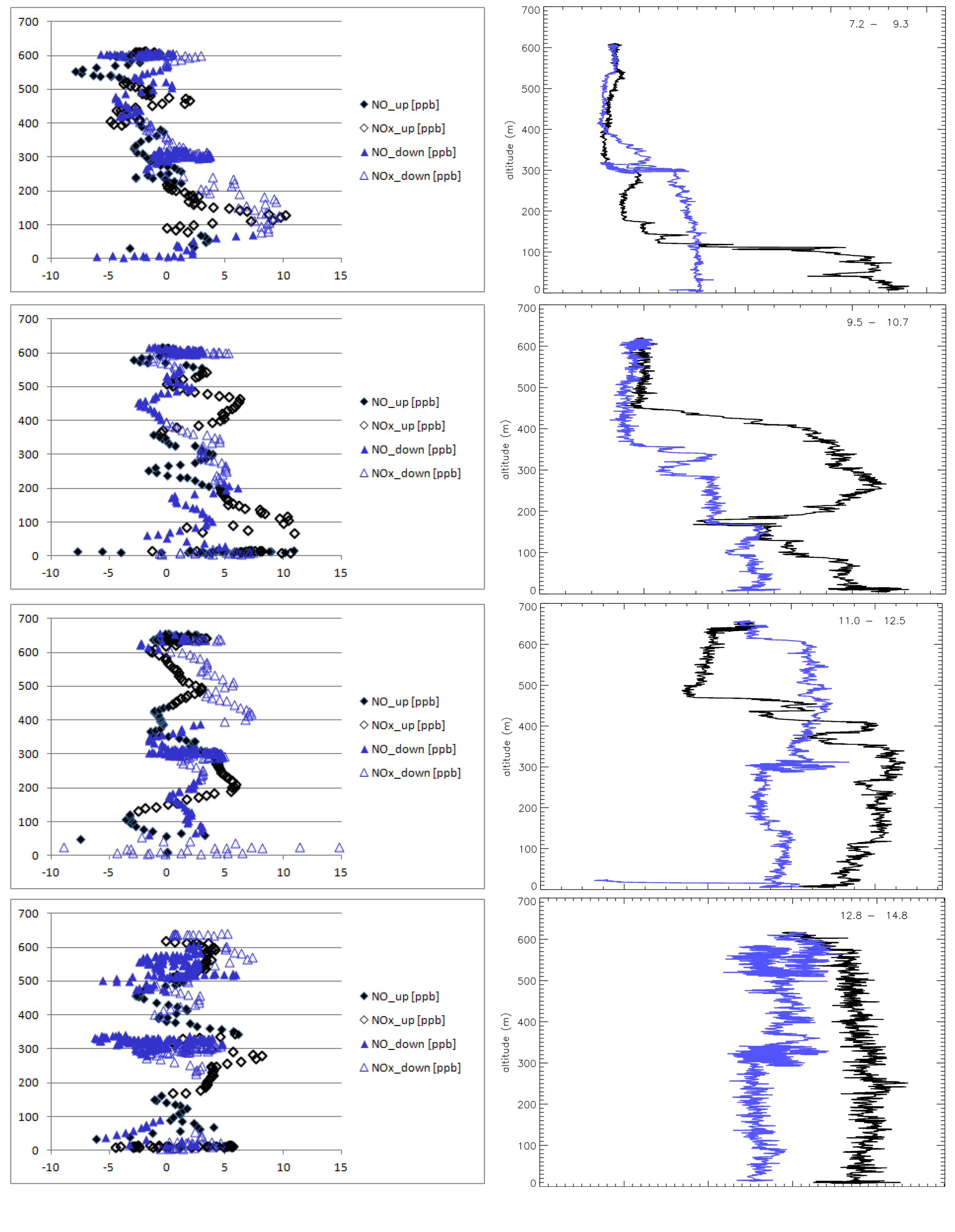
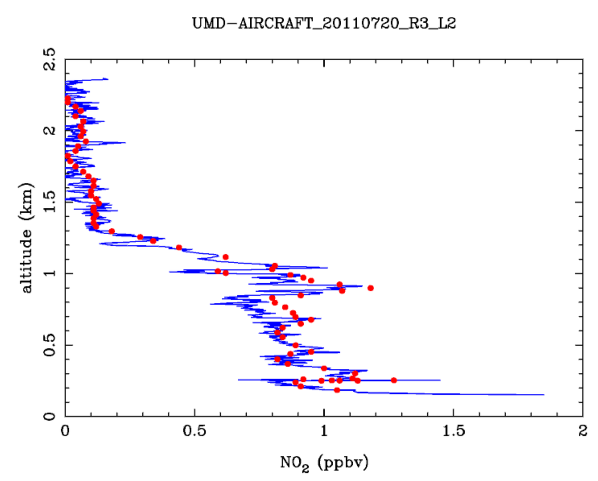


Figure 6, 7. Tethersonde vertical profiles from 20 July 2011; photo tethersonde instrument payload

Goal: Optimize the measurements made by the tethersonde-borne NO/NOx instrument to complement the NO2-sonde for next California DISCOVER-AQ campaign

AIRCRAFT RESULTS: The NO2-sonde was also deployed on 20 July with University of Maryland aircraft. **Figure 8** shows the NO2-sonde profile (**blue**) with CRDS NO2 (**red**).



6. Future Campaigns:

15 JAN – 15 FEB: CALIFORNIA; SEP 2013: HOUSTON, TX

The NO2-sonde will be deployed in both of the upcoming DISCOVER-AQ campaigns. In California the NO2-sonde will be used again with tethersonde and aircraft spiral profile flights and compared to various ground-based data.

7. Acknowledgements:

Millersville University tethersonde data in Figure 6 and tethersonde operational photo courtesy of Dr. Richard Clark and Rebecca Pauly; UMD aircraft data from Russ Dickerson